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DEPOSIT CONVEYANCE MECHANISM AND METHOD FOR CONVEYING DEPOSIT

FIELD OF TECHNOLOGY

The present invention relates to a deposit conveyance mechanism and a method for conveying deposit.

BACKGROUND TECHNOLOGY

A dredging mechanism is disclosed as Japanese Patent No. 3277489.

In the dredging mechanism, a discharge tube is pierced through a bank hole of a water storing place, whose level is lower than water level, the discharge tube is suspended, by a boat floating on the surface of the water, to maintain its level under the water surface, and the discharge tube is vertically moved by an elevating unit provided in the boat so as to move a suction port close to and away from a bottom of the water storing place to generate a pulsating flow, which is a pulsating sucking flow, and a plug flow, in which water with high concentration of deposit parts and water with low concentration of deposit parts alternately appear.

By employing the dredging mechanism, deposits can be efficiently discharged as a solid-liquid two-phase flow without substantially colliding deposits with inner faces of the discharge tube.

The present invention can be applied to the dredging mechanism, and an object of the present invention is to provide a deposit conveyance mechanism and a method for conveying deposit, which are capable of further efficiently conveying deposits.

DISCLOSURE OF THE INVENTION

To achieve the object, the present invention has following structures.

Namely, the deposit conveyance mechanism of the present invention

comprises: a conveying tube having a suction port opened and faced a bottom face of a water storing place on which deposits are deposited, a vertical tube part vertically extending upward from the suction port, a horizontal tube part horizontally extending sideward from an upper portion of the vertical tube part to a discharge section whose level is lower than water level of the water storing place, the horizontal tube part liquid-tightly pierced through a bank hole of the water storing place whose level is lower than the water level of the water storing place, held in the water of the water storing place so as to locate below a hydraulic gradient line and vertically moved so as to move the suction port close to and away from the bottom face of the water storing place, by an elevating unit, in a prescribed cycle; a cup-shaped member provided to the suction port of the conveying tube, the cup-shaped member having a lower part in which the suction port is capable of moving upward and downward; a steam supplying section supplying steam into the cup-shaped member; and a compressed gas supplying section supplying a compressed gas into the cup-shaped member.

Further, in the deposit conveyance mechanism, pressure in the suction port is lowered by inertia of a fluid in the conveying tube, expansion waves are generated and water column separation is caused in a low concentration part of the conveying tube from the suction port when the suction port moves downward together with the cup-shaped member and runs into the bottom face of the water so as to rapidly close the suction port; highly concentrated deposits on the bottom of the water and water, steam and compressed gas in the cup-shaped member are introduced into the suction port and plug and gas plug including the highly concentrated deposits goes upward in the vertical tube section when the suction port is moved upward with respect to the cup-shaped section, a high concentration part in the suction port is sucked as the plug, a small volume of the compressed gas is supplied into the cup-shaped member from the compressed gas supplying

section and the steam, whose volume is greater than that of the compressed gas, is supplied into the cup-shaped member from the steam supplying section; and a coupled vibration-like flow including a solid phase, a liquid phase and a gas phase is generated in the conveying tube so as to convey the deposits to the discharge section by repeating a step of lifting the cup-shaped member, in which supplying the steam and the compressed gas is stopped so as to condense the steam of the gas plug and reduce the volume of the gas plug, and a step of rapidly opening the suction port, in which clear water is introduced into the suction port so as to increase the pressure in the suction port and generate pressure waves to condense the water column separation.

In the case of a highly viscous fluid (Bingham fluid), thick fluid layers are formed on an inner face of a tube and surfaces of solids, so that a flow of the fluid is blocked; in the present invention having the above described structures, viscosity of the fluid layers is reduced by shearing force of strong vibrations caused by cavitations of the water column separation parts (Thixotropy effect), an partial high pressure, which is caused by cavitations of an emulsion flow (emulsion-like flow) in which a microscopic gas flow (micro balloon) in the fluid layers are dispersed, makes a fluid enter spaces between solids, so that the fluid layers are always maintained in a lubricating state or a fluid bearing, and highly concentrated deposits having high viscosity can be efficiently conveyed.

The method of the present invention is a method for conveying deposit in a mechanism including a conveying tube having a suction port opened and faced a bottom face of a water storing place on which deposits are deposited, a vertical tube part vertically extending upward from the suction port, a horizontal tube part horizontally extending sideward from an upper portion of the vertical tube part to a discharge section whose level is lower than water level of the water storing place, the horizontal tube part

liquid-tightly pierced through a bank hole of the water storing place whose level is lower than the water level of the water storing place, held in the water of the water storing place so as to locate below a hydraulic gradient line and vertically moved so as to move the suction port close to and away from the bottom face of the water storing place, by an elevating unit, in a prescribed cycle; a cup-shaped member provided to the suction port of the conveying tube, the cup-shaped member having a lower part in which the suction port is capable of moving upward and downward; a steam supplying section supplying steam into the cup-shaped member; and a compressed gas supplying section supplying a compressed gas into the cup-shaped member, the method comprises the steps of: moving the suction port together with the cup-shaped member until the suction port runs into the bottom face of the water so as to rapidly close the suction port, reduce pressure in the suction port by inertia of a fluid in the conveying tube, generate expansion waves and cause water column separation in a low concentration part of the conveying tube from the suction port; moving the suction port upward with respect to the cup-shaped member so as to suck a high concentration part in the suction port is sucked as plug, supply a small volume of the compressed gas into the cup-shaped member from the compressed gas supplying section, supply the steam, whose volume is greater than that of the compressed gas, into the cup-shaped member from the steam supplying section and make the plug and gas plug including the highly concentrated deposits go upward in the vertical tube section; and repeating a step of lifting the cup-shaped member, in which supplying the steam and the compressed gas is stopped so as to condense the steam of the gas plug and reduce the volume of the gas plug, and a step of rapidly opening the suction port, in which clear water is introduced into the suction port so as to increase the pressure in the suction port and generate pressure waves to condense the water column separation, so as to generate a coupled vibration-like flow including a solid phase, a

liquid phase and a gas phase is generated in the conveying tube so as to convey the deposits to the discharge section.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanation view of a mechanism for dredging a dam; Fig. 2 is an explanation view of Miwa dam; Fig. 3 is an explanation view of a mechanism for fixing a conveying tube (discharge tube) in a bank hole; Fig. 4 is an explanation view of a boat; Fig. 5 is an explanation view of a cup-shaped member and a suction port; Fig. 6 is an explanation view of a double pipe; Fig. 7 is an explanation view of a pressure absorbing section; Fig. 8 is a detailed explanation view of the pressure absorbing section; Fig. 9 is an explanation view showing a relationship between tube loss and solid phase rate; and Fig. 10 is a sectional view of an example of the discharge tube.

PREFERRED EMBODIMENTS OF THE INVENTION

Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

Fig. 1 shows a sectional view of a dredging mechanism, which is an example of the deposit conveyance mechanism. In the present embodiment, the dredging mechanism is applied to a huge dam.

A symbol 10 stands for a discharge tube acting as a conveying tube, and it has: a suction port 12 opened and faced a bottom face of a water storing place 20 (a bottom face 29 of the dam) on which deposits 22 are deposited; a vertical tube part 13 vertically extending upward from the suction port 12, a horizontal tube part 14 horizontally extending sideward from an upper portion of the vertical tube part 13 and having a discharge port 18 opened in a discharge section (a discharge path) 30, e.g., bypass tunnel, whose level is lower than water level of the water storing place20.

Fig. 2 shows a bypass tunnel of Miwa dam located in Nagano Prefecture, Japan.

A diversion dam 33 and a sand control dam 34 are provided on the upper stream side of a dam bank 31. The diversion dam 33 and the sand control dam 34 check large stones so as to reduce amount of solids flowing into the dam, and the large stones checked and deposited can be easily removed after floods. The large stones may be effectively used as materials of concrete, etc..

When a flood is occurred, a gate (not shown) of a bypass path (not shown) near the diversion dam 33 is opened so as to flow fine sands (diameter is about 0.1 mm) into the bypass tunnel, together with flood water, via the bypass path, so that no fine sands are deposited in the dam. Therefore, small particles called wash-loads are deposited in the dam.

In the present embodiment, deposits dredged are discharged through a supplementary tunnel (supplementary path) 32 communicated with the bypass tunnel 30.

The discharge tube 10 is introduced to the supplementary tunnel 32 via a bank hole 24, and its discharge end is opened therein.

The bank hole 24 is formed in a bank 25 of the water storing place 20 so as to locate the discharge tube 10 under a water surface 21 of the water storing place 20.

The horizontal tube part 14 of the discharge tube 10 is perpendicularly bent at an upper portion of the vertical tube part 13 and nearly horizontally extended (an end located on the bank hole 24 side is slightly lower than the other end), and it is located in the water and below a hydraulic gradient line while discharging deposits.

With this arrangement, the discharge tube 10 is filled with water, and the water flows downward by energy of water head difference (in the case of clear water).

The clear water is regarded as a Newtonian fluid whose "ñ" (average density) is about 1.044 (in the case of dredging clay deposited in Miwa dam).

Note that, if 1.5>ñ>1.044, the fluid is a highly concentrated fluid and has characteristics of the Bingham fluid. The Bingham fluid has high viscosity. In the case that solid phase rate is 30 % or more, "ñ" is about 1.5, and if solids are clay, the fluid is called "plastic fluid"; if parts of concentrating solid phases (plugs) are intermittently existed, the flow is called "plug flow". In the plug flow, clay layers (fluid layers), which look like capsule, are sometimes formed on surfaces of the plugs, so the fluid is called "capsule fluid".

The bank hole 24 has a water-tight structure, and it will be explained with reference to Fig. 3.

Symbols 42 stand for roller-shaped holding members, which are provided in the bank hole 24 so as to support and smoothly move the discharge tube 10 in the axial direction thereof.

A symbol 50 stands for a sealing member, which is, for example, a rubber air bag filled with air. The sealing members 50 are provided between the bank hole 24 and the discharge tube 10 (on the upper side and the lower side of the discharge tube 10) so as to liquid-tightly seal a space between the bank hole 24 and the discharge tube 10.

By discharging air from the sealing members 50, the discharge tube 10 is released, so that the discharge tube 10 can be moved in the axial direction.

The holding members 42 are provided on a bank base 44 and arranged on the both sides of the sealing member 50.

A symbol 52 stands for a water gate plate. The water gate plate 52 is fitted in vertical grooves 53 (see Fig. 1) of the bank 25 (see Fig. 1) and capable of sliding therein, and it is vertically moved by driving means so as to open and close a water gate (the bank hole 24).

By moving the water gate plate 52 downward, the discharge tube 10 is clamped by the sealing members 50, so that the bank hole 24 can be liquid-tightly sealed.

Next, a symbol 36 stands for a crane boat (see Fig. 1), on which a crane 37 is provided, the crane 37 suspends the discharge tube 10 so as to vertically hold the vertical tube part 13 and maintain the horizontal tube part 14 under the hydraulic gradient line. A bent part between the vertical tube part 13 and the horizontal tube part 14 is also located in the water. A position of the discharge tube 10 can be freely changed by the crane 37.

As shown in Fig. 4, an elevating unit 38 for vertically moving the vertical tube part 13 or the suction port 12 is installed on the boat 36. The elevating unit has a crank for vertically moving a chain 63 connected with the vertical tube part 13 and moves the vertical tube part 13 of the discharge tube 10, which is suspended by the crane 37, upward about 2 m, then the vertical tube part 13 falls freely.

The elevating unit is not limited to the crank, any means capable of vertically moving the vertical tube part 13may be employed as the elevating unit. The elevating unit is driven by a driving section (not shown), e.g., a motor, a cylinder unit.

Any means for suspending the discharge tube 10 may be employed instead of the crane 37.

Further, a supporting station may be built in the dam instead of the boat 36, and the discharge tube 10 may be supported by the supporting station or the elevating unit may be installed on the supporting station.

A float (not shown) floating on the surface of the water may be employed as the supporting station for supporting the discharge tube 10. Height or level of the discharge tube 10 can be adjusted by controlling air pressure in the float. Further, an electric motor (not shown), which is water-tightly sealed, may be attached to the float so as to vertically move the

vertical tube part 13. A cable (not shown) for supplying electric power to the motor may be pierced through an air supplying tube (not shown) for supplying air into the float so as to prevent a leakage of electricity.

Fig. 5 shows an example of the suction port 12.

As shown in Fig. 5, the suction port 12 has a double cylindrical structure constituted by the inner tube (discharge tube 10) and a cup-shaped member 60. An upper end of the cup-shaped member 60 is closed by a lid 61, and a lower part of the discharge tube 10 (inner tube) is air-tightly and slidably pierced through the lid 61 and enters the cup-shaped member 60. An attachment 62 is fixed to the discharge tube 10 at a position slightly above the cup-shaped member 60, chains 63 are connected to the attachment 62, and the chains 63 are connected to the elevating unit, so that the discharge tube 10 can be moved upward and downward.

The cup-shaped member 60 can be liquid-tightly moved upward and downward with respect to the inner tube 10. The lid 61 of the cup-shaped member 60 and the attachment 62 are connected by a coil spring 65, and the cup-shaped member 60 can be moved, with respect to the inner tube 10, within a stroke range defined by expansion and contraction of the coil spring 65. Therefore, when the inner tube 10 is above the bottom face of the dam, the coil spring 65 is expanded and the cup-shaped member 60 is suspended by the attachment 62.

An inner space of the cup-shaped member 60 is divided by a plate 66 having through-holes, and the inner tube 10 is slidably pierced through the plate 66.

A stopper 67 is fixed to the inner tube 10 at a position below the plate 66, and a cushion 68, e.g., a tire disassembled from a tire wheel, is provided between the stopper 67 and the plate 66. The cup-shaped member 60 is held on the inner tube 10 by the stopper 67.

A grating plate 70 (with through-holes), which is upwardly curved, is

fixed below the cup-shaped member 60. The inner tube 10 is pierced through a center hole of the grating plate 70 and capable of moving upward and downward.

Spherical bodies are provided on the plate 66 of the cup-shaped member 60 and the grating plate 70 so as to adjust their weight. The spherical bodies roll in the cup-shaped member 60, so that clay blocks can be broken and formed into slurry. If minute volume of gasses are included in the clay blocks, they can be released and act as micro balloons described later.

Three chisels 72 (one of them is shown in the drawing) are arranged along an outer circumferential face of the cup-shaped member 60 with regular angular separations.

Lower ends of the chisels 72 are made sharp so as to thrust into the bottom face of the dam when the inner tube 10 and the cup-shaped member 60 fall. Chains for lifting the chisels 72 are respectively connected with the chisels, and the chains are controlled by the boat 36.

As shown in Fig. 4, a steam supplying section (a steam generator: a boiler) 73 and a compressed air supplying section (a compressor) 74, which is an example of a compressed gas supplying section, are provided on the boat 36.

Steam generated by the steam supplying section 73 and compressed air generated by the compressed air supplying section 74 are introduced into an upper part of the cup-shaped member 60 via a flexible double pipe 75.

As shown in Fig. 6, the double pipe 75 includes an outer pipe part 76 and an inner pipe part 77. The steam and the compressed air are supplied to one end of the double pipe 75. Namely, the compressed air is introduced into the outer pipe part 76 via a pipe 79 and a port 78; the steam is introduced into the inner pipe part 77 via a pipe 81a and a port 80a.

The double pipe 75 except both ends is made of an air-tight flexible

material, e.g., rubber, and it is capable of bending and reaching the bottom face of the dam.

The other end of the double pipe 75 is connected to the lid 61 of the cup-shaped member 60 so as to introduce the steam and the compressed air into the cup-shaped member 60.

Since the compressed air having high heat insulativity is introduced into the outer pipe part 76 and the steam is introduced into the inner pipe part 77, condensation caused by cooling the steam can be restricted.

The compressed gas supplying section 74 may supply a carbonic acid gas to the cup-shaped member 60 via the double pipe 75. A high pressure carbonic acid gas is well solved in water; a low pressure carbonic acid gas effervesces. Therefore, micro balloons, which are well dispersed in fluid layers made of slurry, are formed, so that frictional resistance of a fluid can be reduced.

Next, dredging work will be explained.

Before starting the dredging work, the suction port 12 has been lifted about 2 m from the bottom face of the dam. Since the discharge tube 10 is located under the hydraulic gradient line, if water head difference is 5.0 m or more and L/D=1000, water (clear water) fills the discharge tube 10 and flows at enough speed, e.g., 3.6 m/sec. or more, so that the flowing water has enough inertia.

In the present embodiment, the discharge tube 10 is basically located below the hydraulic gradient line, so dredging can be executed by the water head difference. Further, deposits including clay and heavy stones, whose minor axis is about 70 % of a tube diameter, can be conveyed and discharged by adding following actions. Actually, we observed that bolts made of iron (ñ=7.4), which could not be conveyed by ordinary water flow, were conveyed by the water flow.

The dredging work is started after the water flows in the discharge

tube 10 at enough speed.

Firstly, the elevating unit 38 releases the suction port 12 so as to freely fall together with the cup-shaped member 60. If a distance to the bottom face of the dam is 2 m, the suction port 12 reaches the bottom face in three seconds, and if deposits are hard clay including compact fine grains, e.g., wash-loads, the suction port 12 thrusts into the clay deposit layer about 30 cm for 0.1 second.

With this action, the suction port 12 is rapidly closed, but the water in the discharge tube 10 flows by inertia, so that a low pressure part is generated in a border with a high concentration part and expansion waves are formed and transmitted to a down stream. If a pipe line is made of a hard rubber, whose elastic coefficient is E=4GPa, a transmitting speed of the compressional waves is about 200 m/sec.. Since the low pressure part is generated, gasses solved in the water are separated, and pressure is sometimes reduced until saturated steam pressure corresponding to water temperature and water evaporates, so that water column separation occurs and steam cavities are formed. In the case of forming the cavities, cavitation (breaking cavities) occurs. Namely, forming and breaking bubbles (cavities) simultaneously occur.

Forming and breaking steam simultaneously and violently occur in the down stream where the water column separation occurs. The water column separation continuously occurs on the down stream side of each high concentration part of the flow in the discharge tube 10, and the transmitting speed of the water column separation to the down stream is about 20 m/sec.. The water column separation is transmitted by alternately generating the low concentration parts and the high concentration parts as if transverse waves are generated by vertically waving one end of a rope and transmitted in the rope, therefore the horizontal tube part 14 is waved in the direction crossing an axial line thereof like the rope. Energy caused by the waving action

works to flow the fluid in the discharge tube (pipe line) 10. By waving the horizontal tube part 10, solids deposited in a bottom of the tube are floated, so that the solids can be conveyed to a far place.

In the present state, the inner tube 10 (a part of the vertical tube part 13 accommodated in the cup-shaped member 60) is moved upward with respect to the cup-shaped member 60 with supplying the compressed air of the carbonic acid gas into the cup-shaped member 60, then the steam is supplied thereinto. Further, a negative pressure is generated on the down stream side, so that the clay deposits (the high concentrated part or the plug), which is highly concentrated and in which the suction port 12 has been pierced, are rapidly moved in the inner tube 10 upward. Simultaneously, slurry (or clear water) in the cup-shaped member 60 enters the inner tube 10, and the compressed air and the steam enter the inner tube 10 in order. With this action, gas plugs are formed, and an air lift state is occurred by density difference, so that clay plugs having high viscosity can be easily moved in the vertical tube part 13 upward.

When the fluid passes the vertical tube part 13 and enters the horizontal tube part 14, the steam is condensed, so that density around there is made greater, then air or carbonic acid gas are condensed and formed into particles, further the particles are dispersed in the slurry. Since air is formed into particles and dispersed, an air lock can be prevented. Note that, the air lock means blocking a flow a fluid which is occurred when flowing pressure of the fluid is absorbed by air expanding and contracting, which has been stored in a part of the horizontal tube part 14 curved upward.

When the expansion waves are generated, the particles of air or carbonic acid gas break surface tension of water, so that the water column separation can be easily occurred.

Next, the cup-shaped member 60 is lifted (the cup-shaped member 60 is lifted by the stopper 67 when the inner tube 10 is moved upward until

reaching a prescribed level). Since the cup-shaped member 60 is filled with the steam and the compressed air, buoyancy works to the cup-shaped member 60, so that it can be easily lifted and returned to an initial position.

If supplying the steam and the compressed air are stopped immediately after the cup-shaped member 60 is lifted, the steam is condensed and pressure is rapidly reduced to 0.5 atm. or less, so that high pressure clear water, whose pressure is 1.5 atm. or more, rapidly enters. Namely, this action is similar to rapid opening of a valve, therefore pressure waves are generated in the discharge tube 10. The pressure waves are transmitted in the discharge tube 10.

By generating the pressure waves, the gas plugs are rapidly compressed, steam in the gas plugs are condensed and involved in water and collision occurs in the fluid, so that the gas plugs are further compressed and pressure is rapidly increased. At that time, water hammer occurs with elastic variation of volume, and simultaneously inelastic collision between plugs, gas plugs and liquid occur with relative speed difference of 100 m/sec., so that a coupled vibration-like flow including solid phases, liquid phases and gas phases, in which acceleration is rapidly varied, is generated in the discharge tube 10 and plugs can be efficiently conveyed.

Especially, density differences exist in an inertia fluid, and the rapid variation of acceleration (sudden start and sudden stop) or the collision generates pressure difference between objects, so that iron blocks can be conveyed.

Note that, the water hammer means collision which cannot be ignored and in which volume of water is reduced.

By repeating the steps of falling the suction port 12 and lifting the same, the fluid flowing in the discharge tube 10 becomes a plug flow, in which plug parts (high concentration parts) including high concentration of clay and low concentration parts (the clear water parts and the gas plugs

parts; the steam gas plugs are cooled by water in the down stream and disappeared, so that the fluid in the up stream is sucked) including low concentration of clay alternately appear.

When expansion waves (vacuum waves: waves expanding) and pressure waves alternately appear in the low concentration part between the high concentration parts, the fluid flows in the discharge tube 10 as a vibration flow which is violently vibrated therein, the highly concentrated clay can be flown without colliding with an inner face of the discharge tube 10; namely, the clay (deposits) can be properly conveyed to a remote place with low tube resistance. In the case of a long tube in which L (length)/D (diameter) was 1000-1500, highly concentrated deposits could be properly discharged with average flowing speed of 1.3 m/sec.. In an example wherein water head difference was 5m and clay slurry of C_v=7 vol% and ñ=1.1 was flown in a tube of L/D=100, the tube was closed by the slurry stuck on an inner face of the tube and viscosity of the slurry, so that flowing speed of the fluid became zero.

The violent vibration flow in the discharge tube 10 was observed through a transparent part of the discharge tube 10, length of the water column separations reached 50 cm, the fluid flowed backward for several seconds due to negative pressure produce by the water column separations, then the water column separations disappeared by rising pressure in the up stream, and the accelerated flow, whose speed reached 100 m/sec., collided with the flow on the down stream side when the length of the water head columns became 0 cm. Namely, the violent vibration flow was observed.

A relationship between tube loss and true volume concentration (solid phase rate) is shown in Fig. 9. "λ" is resistance coefficient of the whole mechanism. Note that, there are a large number of coefficients are required to precisely calculate the relationship, so that solution diverges, thus the coefficients are put together as "λ", which is a practical coefficient. Fig. 9

shows results of conveying (dredging) deposits having various solid phase rates, wherein the discharge tube had a diameter of 15 cm and a length of 150m, the water head difference was 5.0 m and hydraulic gradient i=0.033.

In the case of a Newtonian fluid, the fluid well flowed at flowing speed of 3.6 m/sec..

In the case of a Bingham fluid, if the characteristic action of the present embodiment (the vertical movement of the vertical tube part 13) is not executed (NO PULSATION), the tube was closed within a short time and no fluid flowed in the tube.

By executing the characteristic action of the present embodiment, an increase of the resistance coefficient was restricted, not only the Bingham fluid but also a plastic fluid having a solid phase rate of 30 % could be conveyed and discharged.

Flowing the three-phase flow, which is caused by alternately generating expansion waves (liquid or gas) and pressure waves (liquid) in the low concentration part between the plug parts which are separately appeared in the discharge tube 10 and which includes the solid phases, the liquid phases and the gas phases (including the water column separations), is similar to sudden start or sudden stop of freight cars (corresponding to the high concentration parts), which are serially connected by couplers (corresponding to the low concentration parts) and freely run down on a long slope, caused by an engine car, namely the highly concentrated fluid having high viscosity can be flowed, without precipitation and deposit, in the discharge tube 10 at low speed or average speed of 1.3 m/sec. toward the discharge port, by small energy, which is generated by an effect (synergistic effect) of a horizontal component of gravity decomposed by the slope and small inertia, as well as the connected freight cars can be started or stopped by small energy, which is generated by extension and contraction of many couplers.

According to measured value, abrasion of the tube is in proportion to a flowing speed squared, so durability of the whole mechanism could be clearly improved several times.

As described above, the steam condensed is involved in the water. On the other hand, a part of the compressed air is solved in the water, but most of the compressed air is dispersed in the thin fluid layers between the inner face of the discharge tube 10 and solids as particles (micro balloons) and discharged together with the fluid. Since the air is dispersed in the thin fluid layers stuck on the inner face of the discharge tube 10, the tube resistance is further reduced, so that the fluid can be preferably discharged. In the case of employing a carbonic acid gas as the compressed gas, a high pressure gas is solved in the water; a low pressure gas effervesces, so that the coupled vibration-like flow can be easily generated.

Even if deposits are hard and highly viscous deposits, which are formed by compressing highly concentrated wash-loads whose solid phase rate is about 30 %, the deposits can be easily discharged.

Supplying and stopping the compressed air and the steam from the sections 73 and 74 are controlled by electromagnetic valves, not shown, and timing of actuating the electromagnetic valves are corresponded to timing of vertical movement of the suction port 12 or timing of actuating the elevating unit 38 including the crank.

Bosses, not shown, are spirally formed on the inner face of the discharge tube 10 as riblets (bosses and recesses are alternately formed like spiral lines), the fluid is rotated to reduce resistance of the plugs, as well as a bullet of a rifle which is fired with rotation, so that deposits can be smoothly discharged. A sectional area of the tube is varied by the expansion waves, and the variation of the sectional area (spin effect) further accelerate the rotation of the fluid (rotational speed of the plug is accelerated by reducing the sectional area, so that shearing speed difference between fluid

layers is made greater).

By cavitation and water hammer occurred in the fluid, a force destroying the discharge tube 10 is made greater. Means for preventing the discharge tube 10 from destruction and improving durability of the mechanism will be explained with reference to Figs. 7 and 8.

Basically, the discharge tube 10 is made of an organic elastic material having enough elastic coefficient "E", e.g., E=4GPa, so as to absorb the force destroying the discharge tube 10 by the discharge tube 10 itself.

In the case of the discharge tube 10 whose diameter is 100 cm or more, preferably the tube is formed by spirally winding a rubber plate, which is formed into a trapezoid in section and whose outer face is reinforced with an iron plate (see Fig. 10).

In Fig. 7, a symbol 80 stands for a float, which is provided to a bended portion between the vertical tube part 13 and the horizontal tube part 14 of the discharge tube 10 and which gives buoyancy to the discharge tube 10. The float 80 is connected to the compressed air supplying section 74 on the boat 36 via a pipe 81 so as to supply compressed air.

Pressure absorbing sections 82 are communicated to the discharge tube 10 so as to absorb increasing and reducing pressure in the discharge tube 10, so that the force destroying the discharge tube 10 can be reduced. The pressure absorbing sections 82 are provided to proper positions of the horizontal tube part 14 of the discharge tube 10, and three pressure absorbing sections are serially provided in the example shown in the drawing.

A concrete example of the pressure absorbing section 82 is shown in Fig. 8.

In the example, a structure of the pressure absorbing section 82 is similar to that of a tire of a motor vehicle.

A symbol 84 stands for a retainer ring made of a metal, e.g., steel, and

the discharge tube 10 is pierced through the retainer ring 84. The retainer ring 84 is fixed on an outer circumferential face of the discharge tube 10 by proper means. The retainer ring 84 is air-tightly communicated to an inner space of the discharge tube 10 via paths 85.

A symbol 86 stands for an outer tube, which is fitted to an outer circumferential face of the retainer ring 84 as well as a tire tube, and it constitutes a tube space, which is tightly closed, with the retainer ring 84. A symbol 87 stands for an inner tube provided in the outer tube 86.

The compressed air and the steam are supplied into the outer tube 86 via a valve 88 of the retainer ring 84 and a hose 89. The outer tubes 82 of the three pressure absorbing sections 82 are mutually communicated by hoses 89, and the compressed air and the steam are supplied to the outer tube 86 of the pressure absorbing section 82, which is located at right end, via the double pipe 75 shown in Fig. 6. The double pipe 75 is communicated to the steam supplying section 73 and the compressed air supplying section 74, which are provided on a boat 90, via pipes.

The compressed air is supplied to the inner tube 87 via a valve 91 of the retainer ring 84, a valve 92 of the inner tube 87, hoses communicated to the valves and a hose 93. The hose 93 is communicated to a compressed air supplying section 95 provided on the boat 90. The inner tubes 87 of the three pressure absorbing sections 82 are mutually communicated by hoses 96.

The pressure absorbing sections 82 have above described structures.

Pressure in the inner tube 87 and pressure in the outer tube 86 are balanced so as to prevent the outer tube 87 from deformation, but the inner tube 87 may be omitted.

When the expansion waves are generated in the discharge tube 10 and pressure is reduced, the compressed air and the steam run into the discharge tube 10 via the holes 85, so that rapid deformation of the discharge tube 10

can be prevented. When relatively large stones 97 flow in the discharge tube 10, the steam supplied in the discharge tube 10 is compressed and pressure is reduced, so that low pressure water column separations are apt to be occurred on the down steam side of the flow of stones 97, the coupled vibration-like flow including the solid phases, the liquid phases and the gas phases is easily generated and plugs and stones can be efficiently conveyed.

When the pressure waves are generated in the discharge tube 10 and pressure is increased, water runs into the outer tube 86 to absorb rapid increase of the pressure, so that rapid deformation of the discharge tube 10 can be prevented.

By the pressure absorbing sections 82, even if cavitations and water hammer are occurred in the fluid, the pressure variation can be absorbed by the pressure absorbing sections 82, so that a pulsation state for conveying solids can be maintained and damage of the discharge tube 10 can be restricted.

Since the pressure absorbing sections 82 act as floats, the horizontal tube part 14 can be easily located under the hydraulic gradient line by properly arranging them on the discharge tube 10.

Structure of the pressure absorbing section 82 is not limited to the above described structure. For example, it may be a mere float capable of absorbing the variation of the inner pressure of the discharge tube 10 by communicating the float to the inner space of the discharge tube 10 via proper means, e.g., path, pipe.

When a deluge is occurred, if a violent stream, e.g. 3 m/sec. or more, is occurred in the water stored in the dam, the discharge tube 10 is sometimes damaged by a great destruction force.

In that case, preferably the whole discharge tube 10 is completely sunk to the bottom of the dam.

A suspending wire is sent out from the boat 36, the pipes 75, 81 and

93 are also sent out, and gasses are discharged from the float 80 and the pressure absorbing sections 82 so as to sink the discharge tube 10 to the bottom of the dam. Water stream near the bottom of the dam is slow, so that damaging the discharge tube 10 can be prevented.

In the present embodiment, the deposits deposited in the dam are dredged, but the present invention is not limited to dredging deposits from dams. The mechanism, of course, can be applied to dredging deposits from ponds, lakes and seas by making a water level difference (pressure difference) between the suction side and the discharge side.

In another embodiment, coals or ores can be forwarded from a cargo ship by filling a tank of the ship with water and discharging coals or ores together with a water flow as described above, namely the mechanism can be applied to mechanisms for conveying stored objects to other places.

As described above, the mechanism can convey iron blocks of ñ=7.4, therefore the mechanism, in which rapid variation of acceleration occurs in a tube, can be applied to mechanisms for collecting useful materials, e.g., methane hydrate, from deep seas.

The mechanism can be preferably applied to systems for conveying crude oil to remote places due to the coupled vibration-like flow including the solid phases, the liquid phases and the gas phases.

The rapid pressure variations in a tube, which are caused by rapid opening and closing the tube, is similar to pulsation of a heart, therefore the expansion waves in the suction port can be applied to an artificial heart conveying red blood cells and blood platelets with blood, further the mechanism can activate (stimulate) deformability of red blood cells and cohesion of blood platelets.

The preferred embodiments of the present invention have been described above, but the present invention is not limited to the embodiments, many modifications will be allowed without deviating the spirit of the

invention.

EFFECTS OF THE INVENTION

In the present invention, the expansion waves (low pressure parts formed into liquid or gas: vacuum waves and the pressure waves alternately appear in the low concentration part between the plugs generated in the conveying tube with separations and the coupled vibration-like flow including the solid phases, the liquid phases and the gas phases (including the water column separations) occurs, as if sudden start or sudden stop of freight cars (corresponding to the high concentration parts), which are serially connected by couplers (corresponding to the low concentration parts), therefore the highly concentrated fluid having high viscosity can be flowed a long distance in the conveying tube by small energy, which is generated by the synergistic effect of gravity (water head difference; pressure difference) and small inertia, as well as the connected freight cars can be started or stopped by small energy, which is generated by extension and contraction of many couplers including springs.